Nushagak River Chinook Salmon Smolt Abundance Feasibility Study, 2014

by

Craig J. Schwanke

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft³/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	$(F, t, \chi^2, \text{etc.})$
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL OPERATIONAL PLAN ROP.SF.2A.2014.17

NUSHAGAK RIVER CHINOOK SALMON SMOLT ABUNDNACE FEASIBILITY STUDY, 2014

by

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Signature/Title Page

Project Title:	Nushagak River Chinook Salmon Smolt Abundance Feasibility Study, 2014
Project leader(s):	Craig J. Schwanke, Fishery Biologist II
Division, Region and Area	Sport Fish, Region II, Dillingham
Project Nomenclature:	Chinook Salmon Research Initiative
Period Covered	15 May 2014–15 June 2014
Plan Type:	Category III
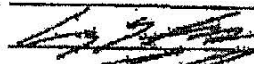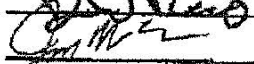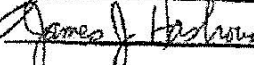
Approval

Title	Name	Signature	Date
Project Leader	Craig Schwanke		2/10/14
Area Management Biologist	Jason Dye		2/10/14
Biometrician	Daniel Reed		2/10/14
Research Coordinator	Jack Erickson		2/13/14
Regional Supervisor	Jim Hasbrouck	James J Hasbrouck	4/17/2014

Chinook Salmon Research Initiative Approval
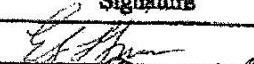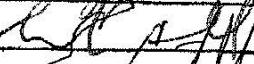
Title	Name	Signature	Date
Fish and Game Coordinator	Ed Jones		2.13.15
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Fisheries Scientist	Eric Volk		3/17/15

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ABSTRACT

There is a lack of information on the juvenile life stage of Nushagak River Chinook salmon, an important indicator stock used by the Department of Fish and Game (ADF&G), Division of Sport Fish, to assess the status of Chinook salmon throughout the state of Alaska. The goal of this project is to assess the feasibility of capturing Chinook salmon smolt emigrating from the Nushagak River. The purpose of this assessment is to obtain preliminary information on the level of accuracy and precision of abundance estimates that could be obtained from a coded wire tag study of juveniles, which would provide information to an age-structured production model, necessary to understand the stock dynamics. During four weeks, a team of 2 technicians will sample the Nushagak River downstream of the confluence with the Iowithla River to Black Point using minnow traps and beach seines, recording numbers and lengths of smolt, and stream conditions.

Key words: Chinook salmon, smolt, *Onchorynchus tshawytscha*, abundance, minnow trap, sein, Nushagak River.

PURPOSE

The Nushagak River Chinook salmon population supports significant commercial, subsistence and sport fisheries. The average annual Chinook salmon harvest from 2002 to 2011 was 47,523 fish in the commercial fisheries, 12,872 fish in the subsistence fisheries, and 6,361 fish in the sport fisheries (Jones et al. 2013). Since 1999, the Nushagak River drainage has sustained an average escapement of approximately 88,600 Chinook salmon as estimated by sonar. This estimate is considered a minimum count because recent research indicates that approximately 50% of the Chinook salmon escapement may migrate outside of the range of the sonar and are not counted (Greg Buck, Fishery Biologist, ADF&G, personal communication). There exists a drainagewide escapement goal range of 55,000–120,000 Chinook salmon based on historical sonar counts.

The Nushagak River Chinook salmon stock is 1 of 12 chosen by the Alaska Department of Fish and Game (ADF&G) as an indicator stock to assess the status of Chinook salmon around the state of Alaska. However, there is a lack of information on juvenile Chinook salmon from the Nushagak River. Age-structured production models, which are widely used to understand a stock's dynamics, require information about processes like recruitment and mortality. To better understand these processes, ADF&G Division of Sport Fish (SF) for Region II is interested in conducting a coded wire tag study that estimates the annual abundance of Chinook salmon smolt emigrating from the Nushagak River and subsequent marine survival. However, before a project of this magnitude is funded, SF Region II needs to assess the feasibility of capturing emigrating smolt from the Nushagak River (Figure 1).
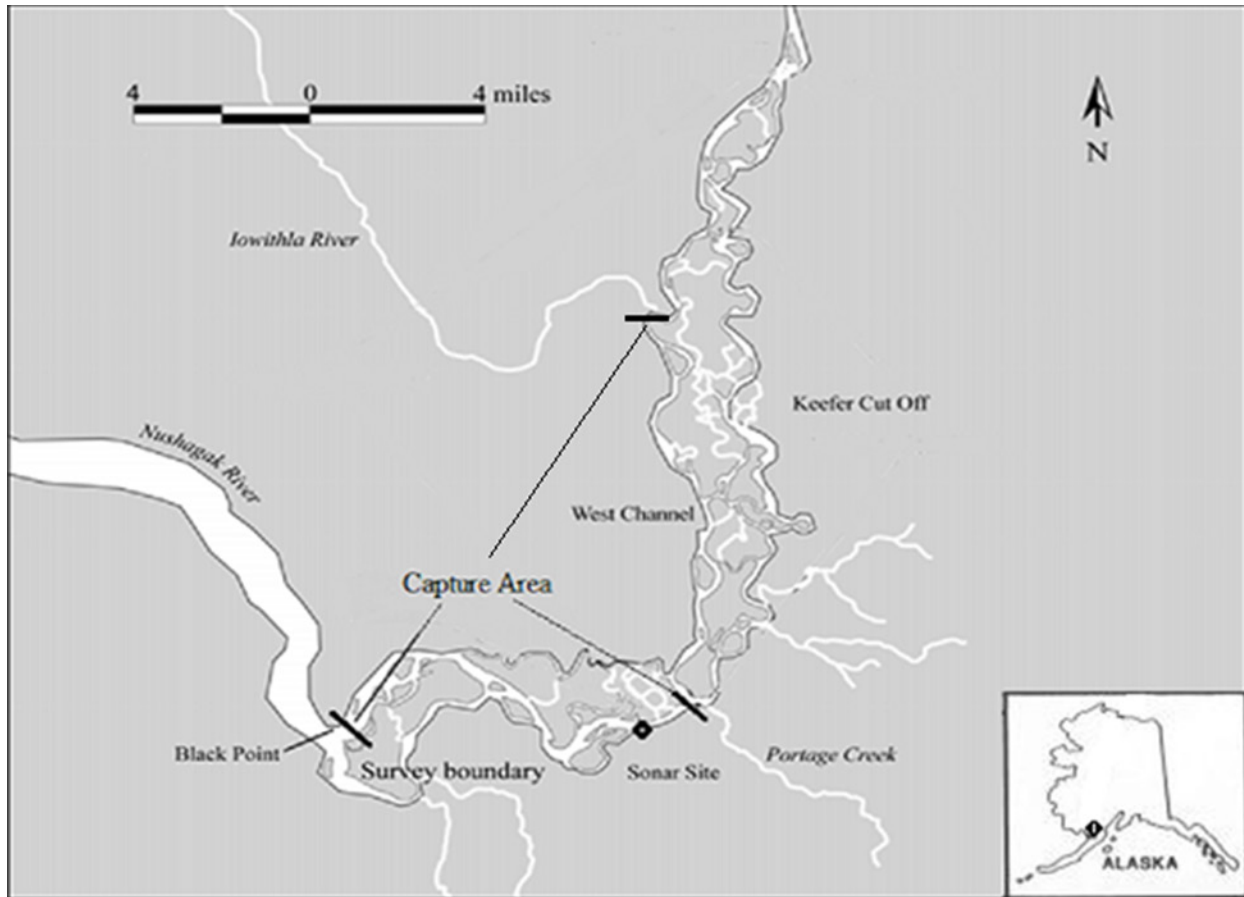
Figure 1.–Map of the lower Nushagak River drainage demarcating capture area.

OBJECTIVES

The objectives for 2014 are

1. to capture emigrating Chinook salmon smolt from mid-May to mid-June using minnow traps and beach seines on the Nushagak River downstream of the confluence with the Iowithla River to Black Point,

2. to determine what level of accuracy and precision the abundance estimates could achieve based on the total number of emigrating Chinook salmon smolt captured,

3. to estimate the mean length of Chinook salmon smolt greater than or equal to 50 mm fork length (FL) captured in 2014 by river section and by week such that the estimated means are ±2 mm of the true means 95% of the time, and

4. to estimate handling mortality of Chinook salmon smolt captured in 2014 by river section and by week such that the estimated proportions are within 6 percentage points of the true values 95% of the time.

METHODS

Study Area and Design

The Nushagak River is the largest river drainage in the Bristol Bay Management Area of southwest Alaska. Ice and snow conditions during the spring salmon smolt emigration can preclude any sampling effort due to the impracticality of sampling through the ice and safety concerns during open water periods with large ice-flows. At this time, there is no concrete information on the timing of emigrating Chinook salmon smolt from the Nushagak River. Studies on the Unalakleet River have shown that Chinook salmon smolt always begin their emigration under the ice; however, studies on the Taku and Stikine rivers in Southeast Alaska have not encountered this situation and consistently produce relatively precise estimates of abundance. To learn migration timing and the location of productive sampling locations on the Nushagak River and to thus increase the likelihood of sampling smolt on the Nushagak River even under adverse conditions, 1 crew of 2 people will capture emigrating Chinook salmon smolt in 2 sections of the Nushagak River: downstream of its confluence with the Iowithla River in the west channel and from the confluence of the west and east channels (Keefer Cut Off) to Black Point (Figure 1).

The timing of ice breakup on the Nushagak River varies from year to year but generally occurs in mid-May. Sampling will commence once the river is ice free and can be safely navigated by skiff. The crew will deploy up to 100 minnow traps (style G-40) baited with salmon roe each day throughout the area. Traps will be deployed along multiple channel banks and backwater areas of the Nushagak River and care will be taken to avoid exposing traps to air via tide changes. Areas of woody debris will be utilized when present and traps will be checked daily. Beach seines will also be used to capture emigrating Chinook salmon smolt (Magnus et al. 2006). Seines are 60–80 ft long and 6 ft deep with one-quarter inch knotless mesh dyed "fish green." Seines will be deployed by hand along multiple channel banks within each area throughout each day after minnow traps have been checked, baited, and redeployed. A set amount of time will be fished each day once it is determined how long it takes to check, bait, and redeploy the minnow traps.

Data Collection

Water temperature and level will be recorded each day. The location of smolt sampling, either downstream of the Iowithla River to the confluence of the west and east channels or downstream of the confluence of the east and west channels to Black Point, will be recorded for each gear type. On a given day, seining sets will be made in only 1 of the 2 sampling sections to assess differences in parameters such as catch per unit effort (CPUE), length, and handling mortality by section. Minnow traps will be fished 24 hours per day, 5 days per week. Beach seine fishing will be a standardized number of hours each day, depending on minnow trap deployment; we expect a minimum of 3 to 4 hours of fishing time each day. All captured juvenile salmon will be placed in aerated totes and transported back to camp and placed in a net pen, designated for each gear type, for sorting and sampling. Daily CPUE information will be tabulated for each gear type fished and by sampling location. Minnow traps will be checked each morning and captured Chinook salmon smolt will be transported back to camp for sampling. Once the sampling of trapped smolt is complete, the crew will commence beach seining. The purpose of transporting captured smolt to camp for sampling is to determine the logistics needed if coded wire tagging were to be conducted and to observe handling mortality. A sample of captured Chinook salmon smolt will be measured for fork length (tip of snout to fork of tail) to the nearest millimeter to

estimate mean length and length composition of the smolt population. A sample size of 116 smolt is necessary to meet the precision criterion for Objective 3, assuming a sample standard deviation (SD) for smolt length of 11 mm, which was the largest SD observed by Pahlke et al. (2010) for Stikine River Chinook salmon smolt. Twice per week, approximately 100 Chinook salmon smolt will be anesthetized with MS222, measured, and each will have the adipose fin clipped. Sampling of fish will occur for 1 day at the Iowithla River confluence capture area and for 1 day from the capture area downstream of the confluence of the west and east channels. Sampled fish will be separated into net pens based on gear type and held overnight to assess handling mortality. The number of mortalities will be recorded at the time of release the following day. If handling mortality is no greater than 10%, a sample of 96 smolt is adequate to meet the precision criterion for Objective 4. The number and species of nontarget fish will also be noted.

Data Reduction

During the fieldwork, all data will be recorded into all-weather field notebooks or on data forms printed on all-weather paper. Following the fieldwork, data will be transcribed into an Excel workbook spreadsheet from which all data analysis will be referenced and performed. The electronic files will be submitted upon completion of the final report and placed into the Divisions Intranet Docushare website; the file name and directory location will be presented in the final report. The spreadsheet will also be archived with the ADF&G Research and Technical Service (333 Raspberry Road, Anchorage, AK 99518) when completed.

Data Analysis

CPUE summary statistics will be calculated for each gear type for the following categories:

1. total Chinook salmon smolt catch

2. by day to examine for temporal patterns

3. by river section (west channel below Iowithla River confluence or below confluence of east and west channels) to examine spatial patterns

CPUE will be estimated as a ratio (Cochran 1977) by the desired time period (e.g., hour, day, 4-h period) gear type, and bank or channel as follows:

$$CPUE_{g,t,l} = \sum_{d=1}^{n_{g,t,l}} c_{g,t,l,d} \Big/ \sum_{d=1}^{n_{g,t,l}} s_{g,t,l,d} \qquad (1)$$

with variance

$$\hat{V}(CPUE_{g,t,l}) = \frac{n_{g,t,l} \sum_{d=1}^{n_{g,t,l}} \left(c_{g,t,l,d}^2 - 2CPUE_{g,t,l} c_{g,t,l,d} s_{g,t,l,d} + CPUE_{g,t,l}^2 s_{g,t,l,d}^2 \right)}{(n_{g,t,l}-1) \left(\sum_{d=1}^{n_{g,t,l}} s_{g,t,l,d} \right)^2} \qquad (2)$$

where

$c_{,g,t,l,d}$ = catch using gear g during time period t at location l for observation d (d=1 to $n_{g,t,l}$),

$s_{g,t,l,d}$ = fishing time using gear g during time period t at location l for observation d, and

$n_{g,t,l}$ =   number of observations for gear g during time period t at location l .

CPUE statistics will be examined graphically and compared by inspection to evaluate logistical similarities and differences between gear and temporal periods. CPUE statistics for combinations of catch categories or temporal periods will be calculated using Equations 1 and 2 and substituting the appropriate sample size for $n_{g,t,l}$. Comparisons of CPUE statistics between gear or time periods will be performed using a t-test with appropriate variance formulas for nonindependent ratio estimates (Cochran 1977).

CPUE estimates over the 4-week sampling schedule will be expanded over a number of plausible run timing scenarios to determine the level of accuracy and precision of any future smolt abundance estimates. The Stikine River drainage, which is smaller in size with lower escapements than the Nushagak River, supports a Chinook salmon population that averaged 112 smolt per spawner from 1998 through 2002 (Pahlke et al. 2010). Assuming 100 smolt per spawner and an average escapement of 90,000, the number of smolt annually emigrating from the Nushagak River would be 9,000,000. If a total of 2,000 adult Chinook salmon are sampled for age, sex, and length (ASL) each year from test fisheries and the subsistence, sport, and commercial harvests, we expect that about 1,600 individuals from each brood year (age .2 through age .5, assuming 80% of the scales sampled from ageing are readable) would be examined for tags. Under this sampling scenario, smolt abundance estimates with relative precision of 25% at 80% confidence could be obtained if a total of 142,839 smolt were successfully tagged during emigration (Robson and Regier 1964). An annual inriver sample of 5,000 adult Chinook salmon (providing 4,000 known-age fish) would require tagging 57,670 smolt in order to estimate smolt abundance with a relative precision of 25% at 80% confidence level. Therefore, the likelihood of obtaining this level of precision and accuracy with future abundance estimates will be determined by the total number of smolt captured during the 4-week sampling period in 2014. A research project is also being developed to estimate adult Chinook salmon escapement for the Nusahagak River in 2014 and subsequent years. This project will be a mark–recapture design and is anticipated to sample a minimum of 2,000 adults from each brood year. The success of the adult research will aid in determining the number of captured smolt necessary to meet desired objectives of future coded-wire-tagging projects. If, as recent research suggests, escapements are approximately 50% larger than indicated by sonar, a much larger sample size would be required for both juveniles and adults.

Run timing will be described as a time-density function for the entire population, where the relative abundance of all Nushagak River stocks that emigrate into the capture area during day t is described by (Mundy 1979):

$$f(t) = \frac{S_t}{\sum\limits_{i}^{days} S_i} \tag{3}$$

where

$f(t)$ =   catch using gear g during time period t at location l for observation d (d=1 to $n_{g,t,l}$),

S_t =   fishing time using gear g during time period t at location l for observation d, and

The mean date of passage ($\bar{t}_j$) by capture area for all Nushagak River stocks will be estimated as follows:

$$\bar{t} = \sum_t t\, f(t)$$ (4)

with the variance of the distribution of dates of passage estimated as

$$Var\ (t) = \sum_t \left(t - \bar{t}_j\right)^2 f_j(t)$$ (5)

Mean length and sampling variance will be calculated using standard sample summary statistics (Cochran 1977). Additionally, length composition estimates will be calculated as described in Cochran (1977). Temporal and spatial differences in length composition will be examined postseason after dividing data into appropriate strata. Temporal and spatial comparisons will be made using the Kolmogorov-Smirnov 2-sample test. The proportion of smolt in each length category will be estimated by

$$\hat{p}_{l,i} = \frac{n_{l,i}}{n_i}$$ (6)

where:

n_i is the sample size for each time and area stratum i;

$n_{l,i}$ is the subset of that sample composed of smolt in length category l, and

$\hat{p}_{l,i}$ is the estimated proportion of the total catch in stratum i composed of fish length l.

The variance of will be estimated using Goodman's (1960) formula for the variance of a proportion:

$$V\hat{a}r\left(\hat{p}_{l,i}\right) = \left(\frac{\hat{p}_{l,i}\left[1 - \hat{p}_{l,i}\right]}{n_i - 1}\right)_{.}$$ (7)

SCHEDULE AND DELIVERABLES

Results from this project will be summarized in a Fishery Data Series Report; a draft of this report will be submitted to the Research Supervisor by 1 March 2015. The FDS report will satisfy any requirements from the funding source (CSRI). Probable dates for sampling activities are summarized below.

Date	Field work	Data analysis and reports
12–18 May	M/S	
19–25 May	S	
26 May–1 June	S	
2–8 June	S	
9–15 June	S/D	
October–November		A
December–March		R

Note: Sampling = (S), Mobilization = (M), Demobilization = (D), Analysis = (A), FDS Report = (R)

BUDGET SUMMARY

Projected FY2014 costs:

Line Item	Category	Budget ($K)
100	Personnel Services	20.0
200	Travel	0.0
300	Contractual	0.0
400	Commodities	5.0
500	Equipment	0.0
Total		

RESPONSIBILITIES

Project Staff	Primary assignments
Craig Schwanke, *Fisheries Biologist II*	Project Leader responsible for supervision of all aspects of the Nushagak River Chinook salmon smolt project, managing the project budget, and writing the final report.
Chase Jalbert, *Fish & Wildlife Technician III*	Crew leader responsible for mobilization, day-to-day project tasks, all aspects of field work, and demobilization.
Cody Larson, *Fish & Wildlife Technician II*	Crew member responsible for mobilization, day-to-day project tasks, all aspects of field work, and demobilization.
Dan Reed, *Biometrician III*	Assists with project design and data analysis.
Jack Erickson, *Fishery Biologist IV*	Final report editing and project support.

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